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Integrative management of open apex with regenerative endodontic therapy: A case report

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ABSTRACT

In clinical practice, treating teeth with an open apex necessitates caution and diligence. In such circumstances, the grade of apical obturation has a direct bearing on the prognosis of endodontic treatment. Previously, a calcified barrier using calcium hydroxide treatment was advised as a therapy option for these patients; however, due to the method's numerous drawbacks, the current management approach advises apexogenesis via regenerative endodontic therapy. This report describes a case of "regenerative endodontic treatment" performed in "immature permanent tooth with pulp necrosis & apical periodontitis" as well as the effectiveness of a PRF-based "regenerative protocol in non-vital young permanent tooth". After 1 year follow up, the tooth was clinically and radiographically asymptomatic and the healing of the apical area is visible.

Keywords: Apexogenesis; mineral trioxide aggregate; trauma.

1. INTRODUCTION

Following the completion of enamel formation, root development begins. Inner and outer enamel epithelia cells meet at the place where the cervical loop is formed, proliferate, and create the Hertwig epithelial sheath. The shape & size of the tooth's root/s are determined by this sheath (Pashley et al., 2006). Closure of the root takes 2–3 years following tooth eruption to complete (Holland et al., 2009). Necrosis of pulp, rhizogenesis disruption and development of periapical lesions usually is sequelae to dental trauma to young permanent teeth which causes loss of neurovascular supply (Kim et al., 2002). Pulp tissue irritation causes significant alterations in pulp microcirculation, leading to necrosis of pulp further causing hindrance to the formation of teeth. Multifactorial etiology including bacteria, trauma, dental procedures causing thermal stimulation, and chemical substances are all strong irritants to the pulp tissue (Kim et al., 2002).

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In paediatric and endodontic dentistry, treating a “young necrotic permanent tooth with an immature open apex” poses a number of obstacles till date. Traditional endodontic treatment with routine chemo mechanical radicular instrumentation and sodium hypochlorite irritant has been observed to be unsuccessful in cleaning and disinfecting the entire dentin wall, especially at the diverging apex (Trope, 2010). Furthermore, during a traditional nonsurgical endodontic procedure, a poor apical seal is a key issue in such instances. Root fracture is a substantial concern when the apical root thickness is thin (Thibodeau & Trope, 2007). An apexification approach using “calcium hydroxide” or “MTA” and “Biodentine” is used in the traditional care of such situations (Felippe et al., 2006; Simon et al., 2007; Sood et al., 2012; Kubasad & Ghivari, 2011). Although this procedure is successful in achieving apical closure, root lengthening is not expected (El Ashiry et al., 2016).

When in vivo study (Iwaya et al., 2001) demonstrated that successful root canal cleaning might result in continuing development of root and closure of the apex in a young necrotic tooth, the field of endodontic treatment took a sharp turn about a decade ago. After 5 months of monitoring, the dentinal wall thickness of the tooth had risen, and closure of the apex with the lesion healing periapically could be seen radiographically. Banchs and Trope (2004) presented a case report on "revascularization," a new therapy approach for open apex management. The method differed from standard apexification techniques in that the canal was disinfected with hypochlorite and chlorhexidine, as well as a “Triple antibiotic paste” (TAP).

Radiographic evidence of continuing thickening of dentin of the root & following apex development in teeth with periapical lesions have been documented in formerly published case reports with the adjunct of blood clot as a “scaffold for regeneration” (Banchs & Trope; 2004; Hargreaves et al., 2008). Owing to its capability in maintaining the pulp vitality by promotion of growth of cells as well as transport of “growth factors” in a sterilised environment, platelet-rich fibrin (PRF) has lately been reported as a reservoir of growth factors & a potentially classic scaffold for regenerative endodontic therapy regimens (Bezgin et al., 2014; Sachdeva et al., 2015; Torabinejad & Turman, 2011; Hiremath et al., 2008). To handle non-vital immature teeth with periapical disease, treatment procedures that exploit this natural process of enhanced healing and tissue regeneration along with comprehensive cleansing of the canals is beneficial. “Regenerative endodontics” is a dental treatment revolution in which RCT restores the health of diseased teeth instead of leaving a "non-vital" or non-living tooth in the oral cavity (Hargreaves et al., 2008).

Evaluating the effects of “regenerative endodontic treatment” performed in “immature permanent tooth with pulp necrosis & apical periodontitis” as well as the effectiveness of a PRF-based “regenerative protocol in non-vital young permanent tooth” was the goal of this mentioned case.

2. CASE HISTORY

A 20 year old woman reported to the “Department of Conservative Dentistry and Endodontics” with an asymptomatic “maxillary left central incisor” that had been fractured for 6 years. The patient provided a comprehensive history, which indicated a 6-year-old RTA that resulted in a fracture of the “maxillary left central incisor”. An Ellis class 2 fracture of the left upper central incisor was discovered on clinical examination (Figure 1 & 2), with no intraoral sinus or swelling. The EPT and cold vitality tests both came back negative.

Figure 1 Preoperative clinical picture

Figure 2 preoperative clinical picture

On percussion, the tenderness was negative. Periodontal probing revealed no abnormalities. A paralleling periapical radiograph indicated inadequate development of root, thinner dentinal wall of root along with open apex (Figure 3), which corresponded to "Nolla's 9th stage of root development". Investigations done clinically & radiographically revealed enough to confirm a diagnosis of "Pulp necrosis with Chronic Apical Periodontitis" in relation to 21. Given the open apex of the tooth, a regenerative endodontic technique using autologous Platelet Rich Fibrin was evaluated as a therapeutic option. The patient consented, and a formal informed consent was acquired. After placement of dam (Figure 4), appropriate access to pulp chamber was acquired devoid of local anaesthetic usage at the initial session. 10 mL 5.25 % NaOCl was used for irrigating the canal without instrumentation with the usage of "Endo-Eze Irrigator Tips" "(Ultradent, South Jordan, UT)" & dried with disinfected paper points. Using a K file of 15 numbers along with an apex locator "(Root ZX; Morita, Tokyo, Japan)", an approximate working length was obtained. Periapical radiograph was used to confirm the working length (Figure 5).

Figure 3 Preoperative Radiographs with 21

Figure 4 Rubber dam isolation with 21

Figure 5 Working length determination with 21

With an ISO no.70 H file & ample irrigation with a solution of 5.25 % NaOCl, nominal manual instrumentation was completed short of the apex (1mm). After the canal was dried, modified triple antibiotic paste (TAP) ("metronidazole 500 mg, ciprofloxacin 200 mg, and Clindamycin 100 mg") was inserted into the root canal (Figure 6) with a no.1 "Buchanan hand plugger" "(SybronEndo, Orange, CA)" & paper points till the apex. Cavit (3M ESPE, Seefeld, Germany) was used for intermediate restoration.

The patient was asymptomatic at the follow-up appointment two weeks later. Without a vasoconstrictor, Lignocaine was administered as a local anaesthetic. For removing TAP, root canal was accessed and irrigation was done with sterile saline. After that, the canal was cleaned with a solution of 5.25 % NaOCl that was left inside for ten minutes (repeating every five minutes). Thereafter, sterile saline was used as a finishing irrigant. Drying of the canal was done, and a no. 25 K file was inserted till it reached the bone, provoking periapical tissue bleeding into the pulp chamber (Figure 7).

Figure 6 Triple antibiotic paste was placed with 21

Figure 7 Bleeding is induced in the canal

Venipuncturing of the anticubital vein was done for collecting 8.5ml of blood and platelet rich fibrin membrane was prepared according to Dohan method. A "10 mL sterile glass tube without anticoagulant" was used to withdraw blood & centrifuged for 10 minutes at 3000 rpm. The resultant in the glass tube after centrifugation consisted of an "acellular platelet poor plasma" on top most layer, a "PRF clot" in the centre, & RBC layer at the bottom (Figure 8). To create a PRF membrane, the PRF clot was squeezed into a piece of sterile gauze. To lower the size of the PRF membrane, it was divided into two halves. With the usage of DOM, PRF membrane was inserted in the canal & compacted lightly with hand pluggers forming an apical barrier at the apex (Figure 9). Manipulation of MTA (Angelus, Londrina, Brazil) was done permitting to the guiding principles of the manufacturer & inserted against the PRF matrix in the apical region of the canal; successive increments were condensed with hand pluggers until a thickness of 5 mm was achieved (Figure 10). The root canal was packed with a moist cotton pellet, & temporary cement was used for sealing of the access cavity.

The next day, the patient was asymptomatic; isolation of the involved tooth was done with dam, after which the temporary restoration & cotton pellet was removed. To confirm the MTA barrier's setting, a hand plugger was tapped against it. GIC and composite were used for the post-endodontic restoration. Resin composite was used to restore the access cavity (Figure 11). (Figure 12: A-D) At 1, 3, 6, and 12 months, the patient was reviewed and evaluated. From the 6 month follow up session, periapical healing could be appreciated radiographically. During the one-year follow-up period, the lamina dura was healthy, and no clinical symptoms were noted.

Figure 8 Prepared PRF Membrane

Figure 9 PRF Membrane Is placed 2-3mm below the CEJ

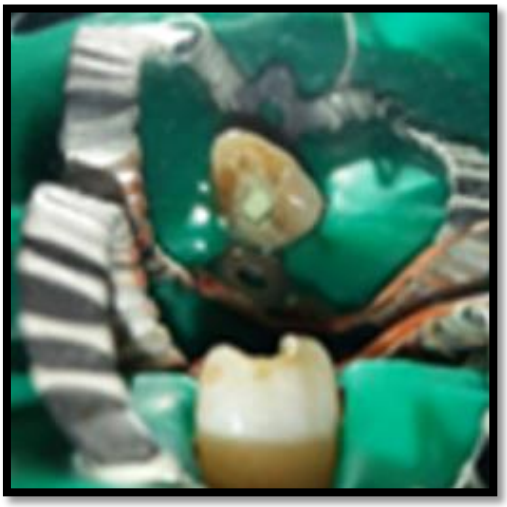

Figure 10 MTA is placed

Figure 11 Post operative radiographs after Postendodontic restoration

(A) 1 month (B) 3 months

(C) 6 months (D) 12 months

Figure 12 Follow up [A-D]

3. DISCUSSION

Many changes have occurred in the way "endodontic therapy" has been performed during the previous 200 years. The conventional approach has undergone various changes, owing to rising patient demand for tooth preservation and improvements in material science and novel technology. Endodontic bioceramics materials are a magnificent entity that has improved the prognosis of many instances that were previously thought to be unattainable (Mandeep Kaur et al., 2017). Pulpal alterations, periradicular inflammation, and inadequate root apex development are all clinical and radiographic symptoms of tooth injury. Since thinner dentinal walls are highly prone to fracture, blunderbuss canals can be a significant threat to an endodontist. Apexification, apexogenesis, and revascularization techniques are now available for the treatment of open apex (Heasman, 2007). Revascularization and apexogenesis with MTA using Platelet Rich Fibrin were undertaken in this patient. Apexogenesis using MTA as an osteoconductive apical barrier is becoming increasingly popular. MTA apical plug thickness and sealing ability have largely been proved to be successful (Torabinejad & Parirokh, 2010).

The disinfection protocol in this case included copious irrigation with NaOCl & TAP as the intracanal medicament. Previously published researches (Banchs & Trope; 2004; Rodrıguez-Benıtez et al., 2015; Rodrıguez-Benıtez et al., 2014; Hoshino et al., 1996; Sato et al., 1996; Thibodeau et al., 2007) have indicated that NaOCl provides adequate disinfection for treatment effectiveness. The goal of achieving maximum disinfection must motivate the judgement to employ the NaOCl concentration in reparative endodontic procedures. Full-strength (5 percent–6%) NaOCl concentrations were employed in about 36 % of the published cases of Reparative endodontic procedures (Diogenes et al., 2013). Conversely, demonstration has shown that 6 percent NaOCl reduces the persistence of "human apical papilla stem cells" in a PRF scaffold (Trevino et al., 2011).

TAP was first utilized in Reparative endodontic Procedures in 2004 (Banchs & Trope, 2004) & it has since been the utmost widely utilised intracanal medication (Diogenes et al., 2013). The mixing of the paste (metronidazole 500 mg, ciprofloxacin 200 mg & Clindamycin 100 mg mixed with sterile water) till a creamy consistency is obtained yields a concentration greater than that suggested by American Association of Endodontists' standardised protocol for Reparative endodontic procedures "(0.01–0.1 mg/mL)" (Diogenes et al., 2013; Ruparel et al., 2012). The antibiotic mixture utilised in REPs has a concentration that is highly powerful against microorganisms while being safe for stem cells (Diogenes et al., 2013).

Studies have proven that formulations of paste can be utilised at 0.1 mg/mL, which is antibacterial but has little influence on survival of SCAP (Ruparel et al., 2012). Conversely, a recent research found that 0.1 mg/mL concentrations were ineffective to eliminate bacteria entirely from simulated "necrotic immature permanent teeth"; 10 mg/mL of TAP was the most efficient medicament which allowed complete elimination of microrganisms from the RC system while allowing a small percentage of SCAPs to survive (Latham et al., 2016). The goal of achieving maximum disinfection while retaining stem cell viability traumatized tooth" (Diogenes et al., 2013). Three parameters determine the efficacy of "pulp revascularization treatment": "root canal disinfection, the existence of a scaffold (blood clot), and the hermetic coronary seal" (Hoshino et al., 1996). For the development of a functioning tissue, 3 fundamental ingredients are required: "growth factors stem cells and a scaffold" (Sato et al., 1996). Cementum bridges may occur as a consequence of the application of MTA, which possesses osteoinductive properties (Thibodeau et al., 2007). Usage of PRF served as intrapulpal matrix. A matrix is required in REPs to establish a physiochemical and biological milieu which supports dental stem cell proliferation, migration, and differentiation (Howard et al., 2010).

PRF is a versatile form that is simple to create and can be utilized as a REP matrix. The fibrinogen in plasma is cleaved to create fibrin, which is the first step in the conduction process. The "fibrin" is subsequently cross-linked with "factor XIIIa" to create a 3D scaffold of fibrin which holds some of the released protein contents, maintains must motivate the decision to use greater TAP concentrations. It has recently been argued that regeneration, is preferable over apexification since the entire root can regrow in a "non- the space for regeneration, & aids as a matrix for endogenous cells. Additionally, this matrix aids in proper placement of "Mineral Trioxide Aggregate" (Anitua et al., 2012; Torabinejad & Faras, 2012; Chandak et al., 2020). Second, it induces the repair &/or regeneration of the "pulp-dentin complex" by delivering growth factors and bioactive molecules (Anitua et al., 2008; Lin & Rosenberg, 2011). The majority of "growth factors" are housed in platelet "alpha granules" & released following activation. Many GF'S & proteins are available in PRGF-Endoret, including "platelet-derived GF, transforming GF beta, epidermal GF, and vascular endothelial GF". "Insulin like GF 1 and hepatocyte GF" are two more growth factors found in the plasma. All of these physiologically active proteins have the capability to impact recruitment of cell, growth, & morphogenesis for healing (Anitua et al., 2012; Anitua et al., 2008).

PRF has a superior clinical outcome than a blood clot in relation of periapical healing, closure of the apex, & thickening of the dentin wall of root (Jadhav et al., 2012). PRF is primarily chosen when a blood clot is inadequate / no bleeding is observed after stimulating the periapical tissue (Zhang et al., 2014; Sedani et al., 2021). When compared to various protocols with a blood clot /without TAP, REPs with NaOCl, TAP, and PRF exhibited the greatest progress in the percentage of teeth with histologic apex closure (34.5%) & vital tissue inside the root canal space (68.8%) (Stambolsky et al., 2016). The success of REPs is measured against three separate criteria, accordance to the "American Association of Endodontics' clinical considerations" for a regenerative therapy. 1^0 goal is to eliminate symptoms & show signs of bone healing; the 2^0 goal is to thicken the wall of the root &/or lengthen the root; and the 3^0 goal is to get a +ve response to pulp vitality testing (Kishen et al., 2016). The 1^0 goal was achieved in this situation, while the 2^0 goal was partially achieved. A modest rise in length of root was acquired, similar to a calcified structure conquering the lumen of pulp, but no overall thickening or root elongation was obtained until 1 year follow up. The tertiary objective was not met.

This conclusion was linked to the presence of SCAPs, which were found even in necrotic teeth (Sonoyama et al., 2008; Huang et al., 2008). It has been confirmed that they possess the ability of self-renewal & differentiation into chondroblasts, osteoblasts, and adipocytes (Abe et al., 2008). Studies have demonstrated that SCAPs can develop into functional dentinogenic cells (Sonoyama et al., 2008). Because the patient is an adult, the chances of preserving the apical papilla are slim; alternative sources of apical mesenchymal stem cells are required. By periapical over instrumentation induced bleeding, cells from inflammatory periapical tissues / periodontal ligaments with MSC properties present in adults are introduced into RC (Chrepa et al., 2015). In vitro and in vivo, these cells possess the ability to produce a mineralized matrix & they may be accountable for the production of cementum &/or bonelike tissue in Reparative endodontic procedures (Seo et al., 2004; Liao et al., 2011).

MSCs present apically are most likely accountable for the formation of mineralized tissue in circumstances when the apical papilla is no longer present. As a result, there is no apical closure or thickening of the dentin wall of the root, which is contrary to the findings seen in cases of Reparative endodontic procedures in younger individuals. Although the capability of multipotent stem cells in replacing injured tissues declines with age (Jones et al., 2011), this could be due to the fact that MSC differentiation capability declines with age, but not the number of MSCs inflow in-to the RC system in adults, which does not alter with age (Chrepa et al., 2015). Conversely, repair of tissue without the "regeneration of a new pulp-dentin complex" with similar original architecture & biological function has been shown in cases of REPs with histologic outcomes. It would be a success clinically, but no evidence of regeneration biologically, in practice (Sedani & Thakkar, 2020).

In the present case, we were able to acquire a repair that met both clinical as well as radiographic criteria; nevertheless no regeneration was appreciated since there was no back up to our findings on histologically or clinically.

4. CONCLUSION

In adults, endodontic rehabilitation with PRF of "necrotic teeth with open apices & apical periodontitis", as well as "nonsurgical endodontic treatment", seems to be anticipated & a promising alternative for periapical tissue restoration based on clinical and radiographic criteria. We were unable to determine if tissue repair or regeneration occurred in the current case due to the lack of a histologic assessment. More research on this intriguing therapeutic approach is required. The use of PRF can assist manage the level of MTA placement and may be a useful option in accelerating the healing process.

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Informed consent

Oral and written informed consent had been got from the woman reported in this case report.

Author Contributions

PC and MC – Initiated the idea of publication and contributed for development of manuscript
MC - Data collection
MC- Diagnosed the condition
SS, AJ, AP- Reviewed and edited the manuscript.

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Conflicts of interest

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

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